

METHOD AND APPARATUS FOR EXTRUSION COATING OF FLUORESCENT LIGHT TUBES

FIELD OF INVENTION

[0001] The present invention relates to coating fluorescent light tubes with a molten thermo-plastic material to form a plastic sheath or sleeve to contain glass shards in the event the light tube is broken or shattered.

BACKGROUND

[0002] A fluorescent light tube includes, among other things, and insofar as pertinent to the present invention, a generally cylindrically shaped glass envelope and end caps provided at either end of the glass envelope. Electrical connecting pins are provided on the end caps to connect the light tube to an electrical power source.

[0003] As is known to those skilled in the fluorescent light tube art, a light tube is subject to breakage if dropped or released from any appreciable height or if the light tube is struck by another object. Upon breakage, the glass envelope shatters into numerous glass shards, posing a threat of injury to bystanders or anyone attempting to handle the broken light tube. Thus, there has existed a need to apply a coating to fluorescent light tubes which upon the glass envelope being shattered will maintain the end caps in association with the light tube and contain the glass shards between the end caps.

[0004] Providing a protective assembly or coating over the exterior of fluorescent light tubes for protecting the light tubes from impact and for retaining glass fragments and debris are known, for example in U.S. Patent No. 5,536,998, which utilizes a pre-formed semi-rigid transparent tube surrounding the glass envelope and held in place by heat shrinkable material heat shrunk to a portion of the end caps and extending over the pre-formed tube. The pre-formed protective tube is of sufficient internal diameter to allow a uniform air space to form between the protective tube and the glass envelope. The disadvantage of this process is the need to select two different yet compatible materials and provide a means for forming the uniform air space between the protective tube and the glass envelope.

[0005] U.S. Patent No. 5,532,549 teaches coating light tubes by attaching adapters to the end caps and, using these adapters, rotating the light tubes on the surface of a bath containing the coating material. To ensure complete coverage, the light tube must maintain contact with the surface of the bath throughout the coating process.

[0006] U.S. Patent No. 4,507,332 teaches coating light tubes by exposing the glass envelop and a portion of the end caps to a fluidized bed of powdered polymeric material and heating the light tube above the melting temperature of the polymeric material to melt and fuse the powder onto the glass envelop and end caps to form the coating on the light tube. Heating the entire light tube, though, risks loosening the adhesive attaching the end caps to the glass envelope, thus compromising the integrity of the light tube.

[0007] Other methods of coating glass envelops include dipping the envelop in a lacquer coating material (U.S. Patent No. 3,959,525), and spraying silicone coatings onto glass envelops (U.S. Patent No. 3,902,946). Although adaptable to "batch" type processing, i.e., applying a coating onto several light tubes at one time, these processes require each light tube be attached to an individual manipulator or adapter before undergoing the coating process, thus making the processes slow.

SUMMARY OF THE INVENTION

[0008] The present invention provides a method for coating fluorescent light tubes without the difficulties of previous methods as those discussed above. The fluorescent light tubes comprise, externally, a hollow glass cylinder sealed on each end by metal end caps. The metal end caps act as both a connection to an electrical power supply for the light tube and also to maintain the structural integrity of the light tube. By the present invention, light tubes are fed through an extruder and coated with a molten thermo-plastic material. The thermo-plastic material adheres to a portion of the end caps such that when cooled, the coating and end caps form a sealed sheath around the glass envelope. This adherence of the thermo-plastic material to the end caps, instead of to the glass envelope, ensures the containment of any glass shards within the sealed sheath if the light tube is broken.

[0009] The end caps include electrically conductive pins. These pins generally extend from the end caps in parallel alignment to the longitudinal axis of the glass envelope. The pins are inserted into a light receptacle and conduct electricity from the receptacle to the light tube as well as supporting the light tube within the light receptacle. Thus, the pins must remain free of coating material. When using an extruder to coat the light tubes, three avenues are available to address the need to keep the coating material from contacting the pins: 1) cover the pins during coating; 2) clean the pins after coating; and 3) coat the light tubes in such a manner that prevents the coating from contacting the pins

without the need to cover the pins while ensuring that the coating is applied evenly and adheres to the end caps. Covering the pins requires the use of either a disposable cover or a cover capable of being removed, cleaned of the coating material and reused. Further, because the coating is applied to both the light tube and the cover, removing the cover may tear, stretch, or otherwise damage the coating on the light tube, rendering the coating ineffectual. Finally, the covers must be aligned to fit around the pins snugly or else the coating material may seep around the cover and contact the pins. Thus, using a cover to protect the pins is undesirable. Likewise, cleaning the pins after coating is also undesirable because of the risk of damage to the pins and the coating, as well as the time required to ensure each pin is completely free of the coating material. Thus, the desirable choice is to coat the light tubes with an extruder in such a manner as to ensure complete application of the coating material while eliminating the need to protect the pins during the coating process.

[0010] Basically, the method of the present invention comprises coating the light tubes with molten thermo-plastic material as the light tubes are fed, sequentially, through a cross head extruder. Prior to entering the cross head extruder, the end caps of the light tubes are heated. The pre-heating is performed to ensure that the coating adheres to the end caps and not to the glass cylinder so that, if broken, the end caps and the coating contain all of the glass shards. The light tubes are then conveyed, sequentially and in longitudinal alignment with one another, to the cross head extruder. A coating of molten thermo-plastic material is extruded about each light tube. A vacuum is applied in the extruder to evacuate air from between each light tube and the coating to promote direct intimate contact of the coating with each light tube. Gaps are formed between each sequentially fed light tube and these gaps are also coated as the sequential light tubes are fed continuously through the extruder. Upon exiting from the extruder, the chain of now coated light tubes and gaps are cooled to below the softening temperature of the thermo-plastic material. After cooling, each light tube is separated from the chain of light tubes. This may be done in a variety of ways either by manual manipulation or by use of an automatic device. The separated light tubes are then conveyed to a finishing station where the end caps of the light tubes may be trimmed of excess coating, labeled, inspected and readied for packaging.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Fig. 1 is a plan view illustrating one design of a fluorescent light tube.

[0012] Fig. 2 is a schematic of the apparatus and method of the present invention.

[0013] Fig. 3 is an expanded drawing of the vacuum assembly attached to the cross head extruder.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0014] Referring to Figure 1, and for the purposes of this invention, fluorescent light tubes 15 comprise a glass envelope 13 having end caps 11 attached to opposing ends of the glass envelope 13. Electrically conductive pins 9 extend from at least one end cap 11. Referring to Figure 2, apparatus 40 for coating light tubes 15 according to the present invention comprises a heating table 50, a cross head extruder 65 with a vacuum assembly 70 attached thereto, and a control unit 100 connected therewith and controlling individual steps of the coating process. Preferably, the apparatus 40 also includes a cooling station 75, a cutting station 85, and a finishing station 95. An entrance conveyor system 55, disposed between the heating table 50 and the cross head extruder 65, impels the light tubes 15 sequentially, in longitudinal alignment with one another from the heating table 50 to the cross head extruder 65. An exit conveyor system 80, disposed between the cooling station 75 and the cutting station 85 further impels the light tubes 15 sequentially to the cutting station 85 after the light tubes 15 have been coated and the coating has been cooled. An accelerating system 90, located after the cutting station 85, conveys the light tubes 15 to the finishing station 95. A passive conveying system maintains the light tubes 15 in proper alignment while traveling through the apparatus 40.

[0015] The heating table 50 comprises infra-red panels arranged to heat the end caps 11 of a plurality of light tubes 15. Infra-red panels are known by those of the coating art and are used extensively with fluidized bed type coatings. The infra-red panels are preferably controlled by the control unit 100.

[0016] Cross head extruders have been used for coating articles that do not have voids or gaps therein, such as wire and cable. A die within the cross head extruder 65 of the present invention conforms to the cross-section of the light tubes 15 and regulates the coating thickness. The cross head extruder 65 is connected to a vacuum hopper loader (not shown) through which is received the thermo-plastic material, typically in pellet form. The thermo-plastic material is plastized in the extruder 60 and applied to the light

tubes 15 via the cross head 65. The vacuum assembly 70 attached to the cross head extruder 65 applies a vacuum during extrusion, thus evacuating air from between each light tube 15 and the molten thermo-plastic material, thus drawing the molten thermo-plastic material into direct intimate contact with each light tube 15. The vacuum combines with the length of gap 17 between sequential light tubes 15 to prevent the molten thermo-plastic material from contacting the pins 9 on the end caps 11 of the light tubes 15. The vacuum hopper, extruder 60, cross head 65 and vacuum assembly 70 are preferably controlled by the control unit 100.

[0017] One embodiment of the vacuum assembly 70 is shown in greater detail in Figure 3. The vacuum assembly 70 comprises a first vacuum array 710 connected with a second vacuum array 760, which is in direct communication with the cross head extruder 65. The first vacuum array 710 comprises an entrance seal plate 720 attached to an entrance of a vacuum chamber 740. A high temperature seal 730 disposed between the entrance seal plate 720 and the vacuum chamber 740 provides an air tight seal therebetween. A vacuum supply 750, preferably a vacuum pump (not shown) is attached to the vacuum chamber 740. An exit flange 745 of the vacuum chamber 740 of the first vacuum array 710 connects to an entrance flange 775 the second vacuum array 760. A high temperature seal 765 disposed between the exit flange 745 and the entrance flange 775 provides an air tight seal therebetween. The second vacuum array comprises the entrance flange 775 and a vacuum chamber 770 attached to a vacuum supply 780, preferably a vacuum pump (not shown). The vacuum chamber 770 of the second vacuum array 760 is attached to the cross head extruder 65 in a direct, fluid connection. A light tube 15 enters the vacuum assembly 70 through the entrance seal plate 720, travels through the first vacuum array 710 and the second vacuum array 760, and enters the cross head extruder 65. The vacuum applied in the vacuum assembly 70 evacuates air around the light tube 15, promoting a direct and intimate contact between the light tube 15 and the thermo-plastic material extruded about the light tube 15 within the cross head 65.

[0018] The cooling station 75 cools the coating on the newly coated light tubes 15 and gaps 17 to below the softening temperature of the coating, thus permitting additional manipulation of the light tubes 15 in a timely fashion. The cooling of the coating also prevents the coating from turning opaque, which adversely impacts the brightness of the light tubes while in use. The cooling station 75 comprises a water bath, an air cooling

system, or a combination thereof. Preferably, the cooling station 75 comprises a water bath capable of providing a constant supply of chilled water to cool the coating on the light tubes 15. The cooling station 75 may be controlled manually or, preferably, be controlled by the control unit 100.

[0019] The cutting station 85 separates individual light tubes 15 from the chain formed by the continuous coating of sequentially fed light tubes 15 by severing the coating encircling the gaps 17 formed between the light tubes 15. The cutting station 85 comprises a cutting tool. The cutting tool comprises a shearing system, hot wire, shears, knives, or a combination thereof, and may be manually or automatically actuated. Preferably, the cutting tool is a shearing system that melts or otherwise slices through the coating encircling the gaps 17. The cutting station 85 is preferably controlled by the control unit 100.

[0020] The accelerating system 90 comprises a series of drive wheels operated independently of and at a greater travel rate than the entrance and exit conveying systems 55, 80. The accelerating system 90 provides a burst of speed to the separated light tubes 15, quickly impelling the light tubes 15 to the finishing station 95. The sudden increase in travel rate of the light tubes 15 also ensures that the separation of the light tubes 15 is complete after exiting the cutting station 85. The accelerating system 90 is preferably controlled by the control unit 100.

[0021] The finishing station 95 comprises a trimmer tool and a labeling tool. The trimmer tool is used to remove the remnants of the severed coatings encircling the gaps 17 from the end caps 11, thus providing clean edges on the end caps 11 to protect the integrity of the coating adhered to the end caps 11 and to allow the light tubes 15 to be easily fitted into a light receptacle for use. The trimmer tool comprises a hot wire, shears, knives, razors or a combination thereof. The trimmer tool may be manually manipulated or, preferably, controlled by the control unit 100. The labeling tool places a label on the coating and is comprised, preferably of an ink jet type printing system. The labeling tool may be manually or automatically actuated. Preferably, the labeling tool is controlled by the control unit 100.

[0022] The entrance and exit conveyor systems 55, 80 comprise a series of indexed drive wheels controlled by the control unit 100. The indexing of the drive wheels is regulated by encoders and servos connected to each of the entrance and exit conveyor systems 55,

80. The entrance and exit conveyor systems 55, 80 are synchronized to ensure a consistent travel rate is maintained for the light tubes 15 undergoing the coating process.

[0023] The passive conveyor system (not shown) comprises a series of non-driven wheels spaced along the travel path of the light tubes 15 undergoing the coating process and is used to direct the light tubes 15 on the travel path.

[0024] The method of the present invention, utilizing the apparatus 40 discussed above begins by placing a plurality of light tubes 15 upon the heating table 50. The end caps 11 of each of the plurality of light tubes 15 are heated before the plurality of light tubes 15 engage the entrance conveyor system 55. The entrance conveyor system 55 impels the plurality of light tubes 15 sequentially and in longitudinal alignment with one another toward the cross head extruder 65. The sequential light tubes 15 are continuously fed to the cross head extruder 65 by the entrance conveyor system 55. Each light tube 15 is coated with a molten thermo-plastic material while a vacuum is applied to evacuate air from between each light tube 15 and the coating to promote direct intimate contact of the coating with each light tube 15. The sequential feeding of light tubes 15 and the longitudinal alignment thereof creates gaps 17 between each of the light tubes 15. The gaps 17 are also coated as the sequential light tubes 15 are fed continuously through the cross head extruder 65, thus creating a chain of coated light tubes 15 connected by the coated gaps 17. Upon exiting the cross head extruder 65, the coated light tubes 15 and gaps 17 immediately enter the cooling station 75 wherein the light tubes 15 and gaps 17 are passed through a water bath of circulating chilled water, cooling the coating to below the softening temperature of the thermo-plastic material. The exit conveyor system 80 impels the chain of coated light tubes 15 and gaps 17 to the cutting station 85. There, a shearing system severs the coating encircling the gaps 17 between the light tubes 15, thus separating individual light tubes 15 from the chain of coated light tubes 15. The individual light tubes 15 are then quickly moved away from the chain of coated light tubes 15 by the accelerating system 90, which speedily impels the individual coated light tubes 15 to the finishing station 95. At the finishing station 95, the individual coated light tubes 15 are trimmed of excess coating and labeled. The light tubes 15 may then be inspected and readied for packaging.

[0025] The coating applied to the light tubes 15 by the cross head extruder 65 is maintained within a desirable thickness range to ensure that the light tubes 15 are

completely covered by a consistent thickness of thermo-plastic material. The thickness may vary from about 10 mil to about 22 mil, preferably between about 14 mil and about 20 mil, and more preferably between about 16 mil and 18 mil.

[0026] The gaps 17 between the sequential light tubes 15 are maintained at a desired length to ensure that each light tube 15 is coated without interference from a preceding or succeeding light tube 15 and to prevent the coating from contacting the pins 9 of the end caps 11 of the light tube 15. The length of the gaps 17 may be regulated by adjusting the travel rate of the light tubes 15 undergoing the coating process. The gaps 17 have a length of between about 0.5 inch and 2.5 inches, preferably between about 1.0 inch and about 2.0 inch, and more preferably about 1.5 inch.

[0027] The travel rate of the light tubes 15 is regulated by adjusting the speed of the series of indexed drive wheels of the entrance and exit conveyor systems 55, 80. The travel rate of the light tubes 15 is preferably between about 16 ft/min and 60 ft/min.

[0028] It will therefore be readily understood by those persons skilled in the art that the present invention is susceptible of broad utility and application. Many embodiments and adaptations of the present invention other than those herein described, as well as many variations, modifications and equivalent arrangements, will be apparent from or reasonably suggested by the present invention and the foregoing description thereof, without departing from the substance or scope of the present invention. Accordingly, while the present invention has been described herein in detail in relation to its preferred embodiment, it is to be understood that this disclosure is only illustrative and exemplary of the present invention and is made merely for purposes of providing a full and enabling disclosure of the invention. The foregoing disclosure is not intended or to be construed to limit the present invention or otherwise to exclude any such other embodiments, adaptations, variations, modifications and equivalent arrangements, the present invention being limited only by the claims appended hereto and the equivalents thereof.